Project for impacts assessment of practices on the comprehensive fertility of soils under oil palm

2012 – 2013 - first achievements:
Spatial variability around palms and temporal variability after EFB application

Carron M.P. and Snoeck D.
UPR 34 - Performance of Tree Crop-based Systems

cirad

smart agribusiness and food

Oil palm Context:

1) Soil fertility and Biodiversity conservation are two important issues in Global Change.

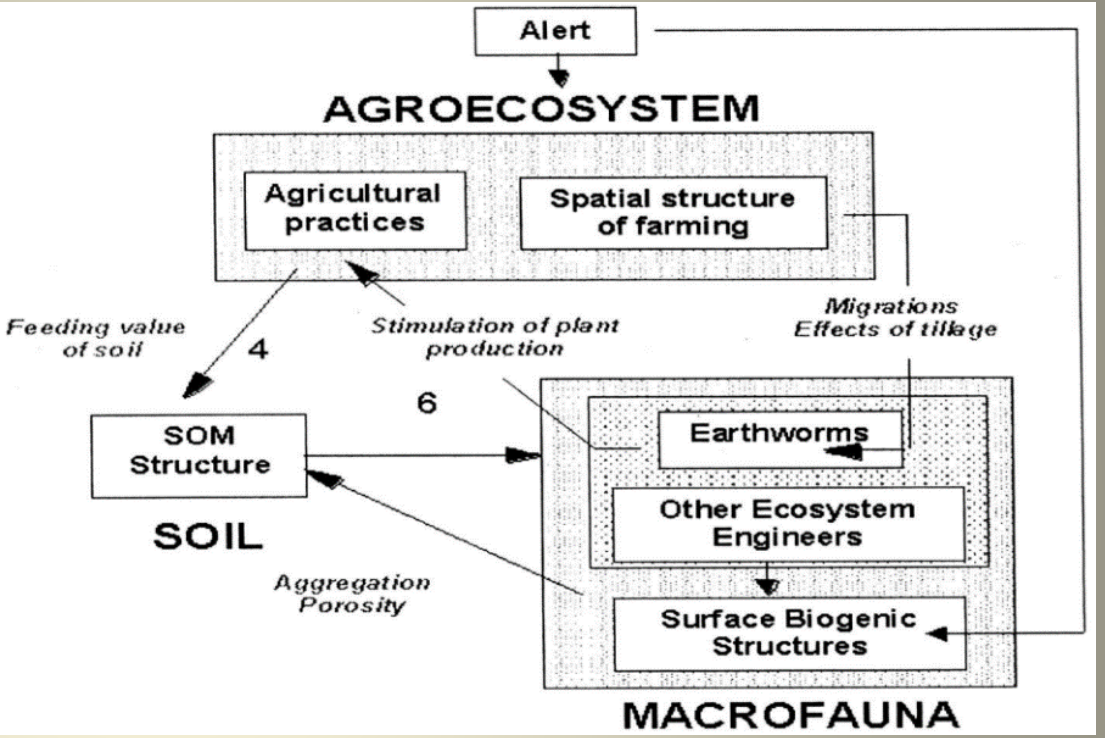
2) Oil palm production is currently managed by periodic foliar/rachis diagnosis to control the use of mineral fertilizers. (Caliman *et al*, 1994).

3) It is very difficult to directly control the yields through soil analysis due to the complexity of phenology and source-sink interactions (Legros *et al*., 2009). Consequently, the soil was gradually marginalized in the management protocols.

4) The need to recycle large volumes of harvest wastes (EFB, POME, Compost) raised the following question: **"How to manage these wastes and mineral fertilizers regarding the comprehensive soil fertility?"** (Oviasogie *et al*., 2010; Abu Bakar *et al*., 2011) Currently, inputs of organic matter are empirical or calculated on the basis of their mineral equivalents (Hornus, 1992).

Soil scientific context:

- Organic residues can be considered as food for the soil biota (Lavelle *et al.*, 2001; Tomich *et al.*, 2011).
- The works of Blanchart (2006) and Bonkowsky (2009) suggest an analytical approach to assess the impact of organic inputs on the comprehensive soil fertility.



« Why feeding the soil macrofauna", in Lavelle *et al.*, 2001

And particularly the biota:
Biomass + functional and taxonomic biodiversity.

Mutualistic relationships in soil biological systems of regulation

Organic inputs
Plant cover, Fronds, EFB, POME, Compost

Mineral Fertilizers
N, P, K, Mg, B

Why the Soil Food Web must be supported:
- Soil Structure – « green water »
- C conversion – Soil Organic Matter
- Nutriment recycling: stocks & fluxes: C, N, K, P
- Reducing diseases by balancing belowground preys/predators populations

(from Lavelle et al., 2001)

Macrofauna
Ecosystem Engineers
Fragmentizers

Bacteria – Fungi
Microbial populations
Chemical Engineers
Decomposers

Microfauna – Nematodes
Regulators

Physical & Chemical traits

The objective of the current project is to answer the following Research Questions:

- Do organic residues applications (EFB, POME, Compost) under oil palms modify the traits of the comprehensive soil fertility?
- How Biota assessment can lead to a more efficient management of association between organic and mineral fertilizations, wherever comprehensive soil fertility is concerned?

→ **Enhance the actions of the biota to improve physical and chemical traits.**

2012 – 2013 First achievements were to assess soil biodiversity under oil palms. We worked in two steps:

1) Assess the **spatial soil variability** around the palm.
2) Assess the **temporal soil variability** after EFB application.

Scientific Partnership

- UPR Tree-crop based Systems: – M.P. Carron, Coordinator
  – D. Snoeck.
- Smart-RI – J.P. Caliman & scientific staff.
- Elisol-Environment (Nematodes): – C. Villenave.
- With the scientific support of the UMR Eco&Sols – E. Blanchart, D. Lesueur and A. Robin.

First Results : → Spatial variability around the palm (Master Q. Auriac, 2012)

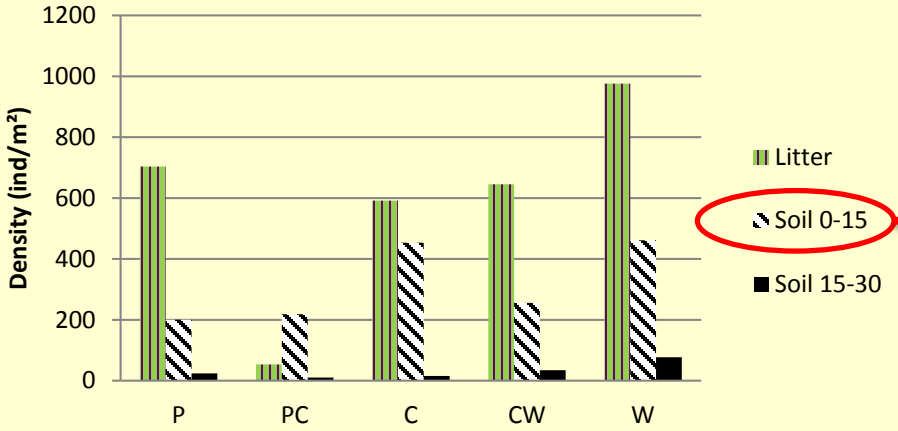
	Physical & chemical traits	Macro-fauna	Nemato-fauna	Micro-organisms
W	X	X	X	X
CW	X	X		
C	X	X	X	X
PC	X	X	X	X
P	X	X		

→ Spatial variability (Master Q. Auriac, 2012)

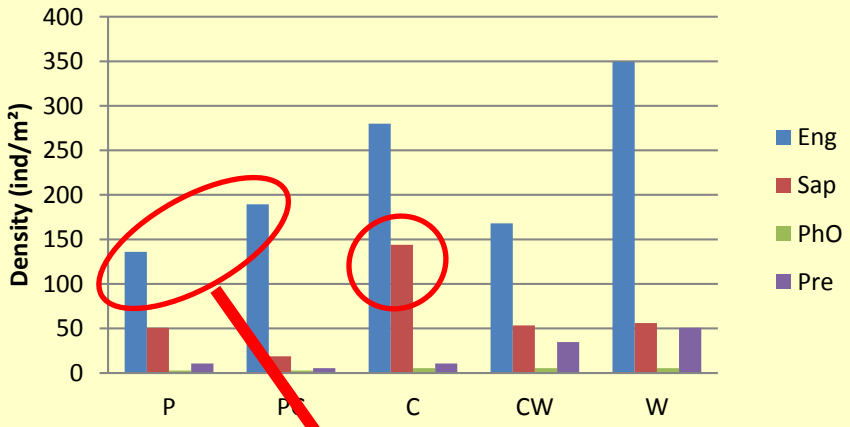
Macrofauna

3 months after EFB application

With EFB – Total macrofauna



Soil 0-15 cm - Functional groups



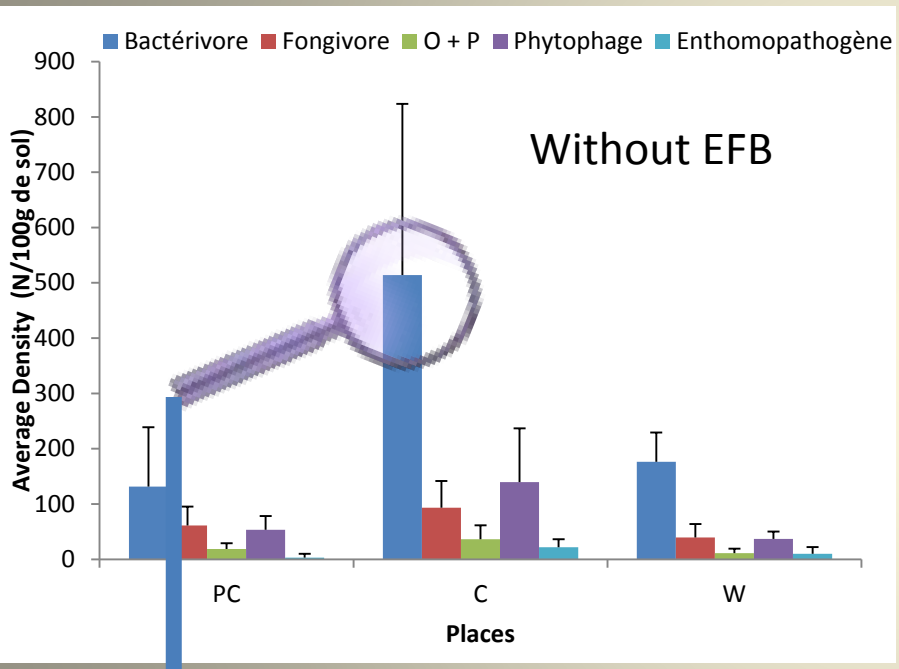
Engineers	Ants, earthworms, termites
Saprophagous	Dermaptera, Millipedes, Coleoptera, cockroach, Isopedes, mites, Diptera
Phytophagous	Hemiptera, Orthoptera, beetle larvae, Mollusk, Phasmes
Predators	Spiders, Centipedes, Opillions, Pseudoscorpions, Mantis

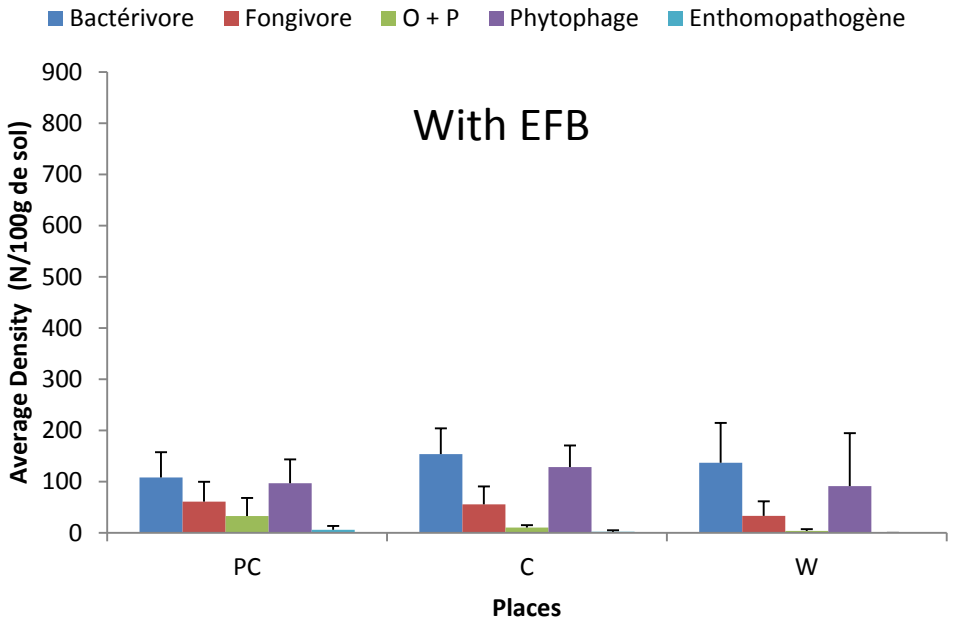
Ind/m²	P	PC
Ants	78	5
Earthworms	16	173

→ Spatial variability (Master Q. Auriac, 2012)

Nematofauna

Analysis was made 3 months after EFB application on P zone
Soil depth: 0 – 15 cm

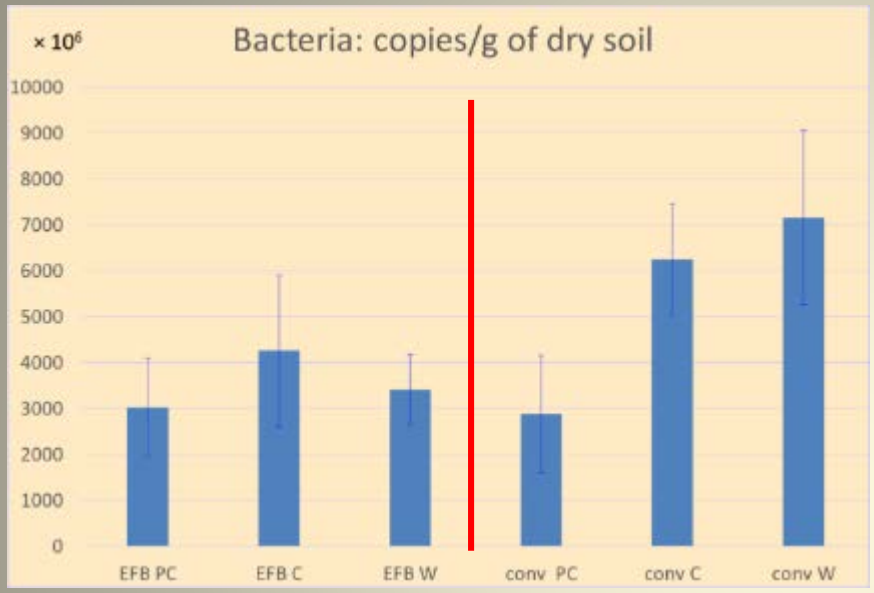


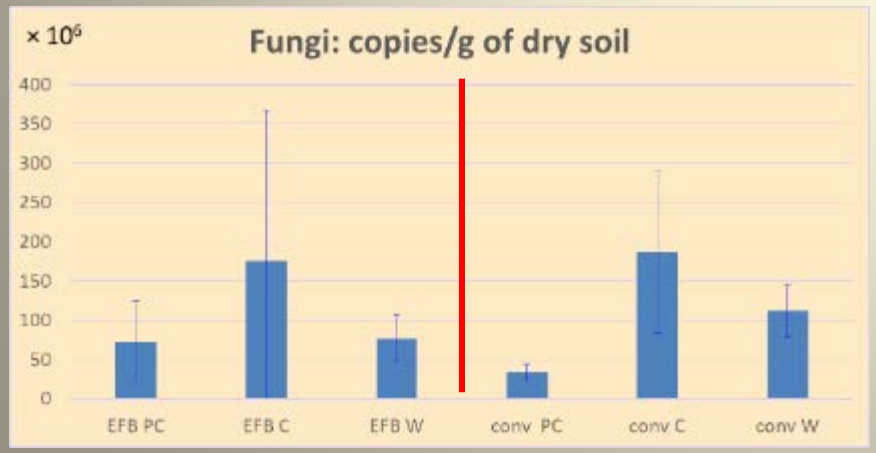


Associated with very high content of Phosphorus and high abundance of earthworms

Analysis by Elisol-Environnement , Montpellier France (Cecile Villenave)

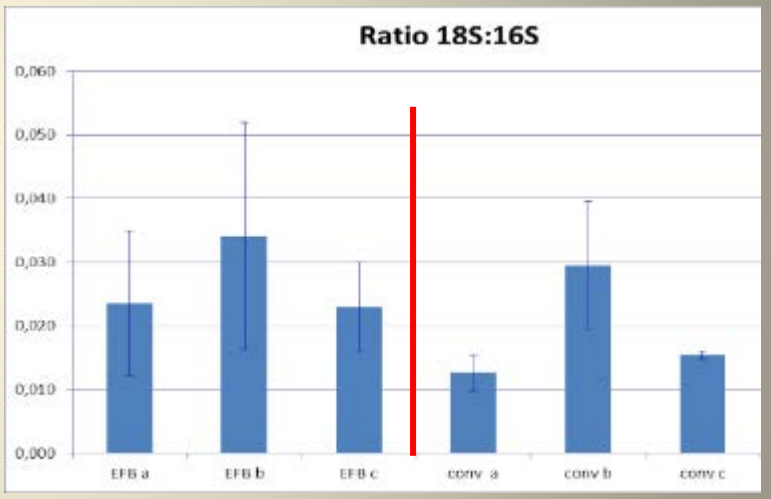
→ Spatial variability (Master Q. Auriac, 2012)





Analysis was made 3 months after EFB application on P zone.

Soil depth: 0 – 15 cm

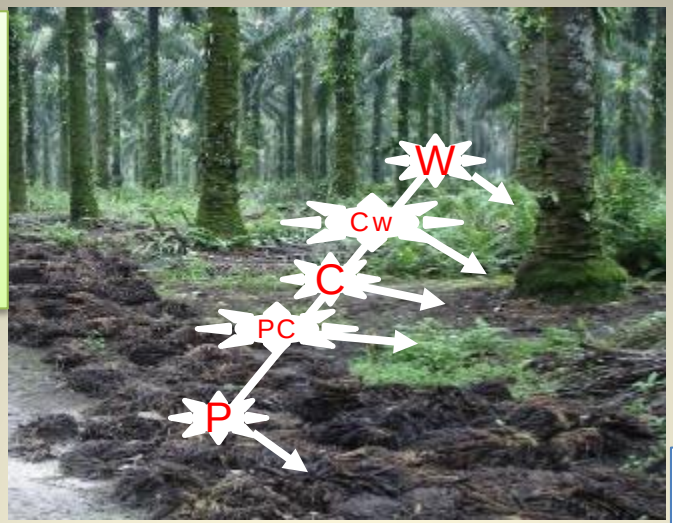


Analysis by Eco&Sol, Cirad research Unit (Agnes Robin/Didier Lesueur)

→ Spatial variability (Master Q. Auriac, 2012)

Analysis was made 3 months after EFB application on P zone.

Soil depth: 0 – 15 cm



Reference = W zone "with EFB"

No difference

+/++/+++ More than "W zone in EFB"

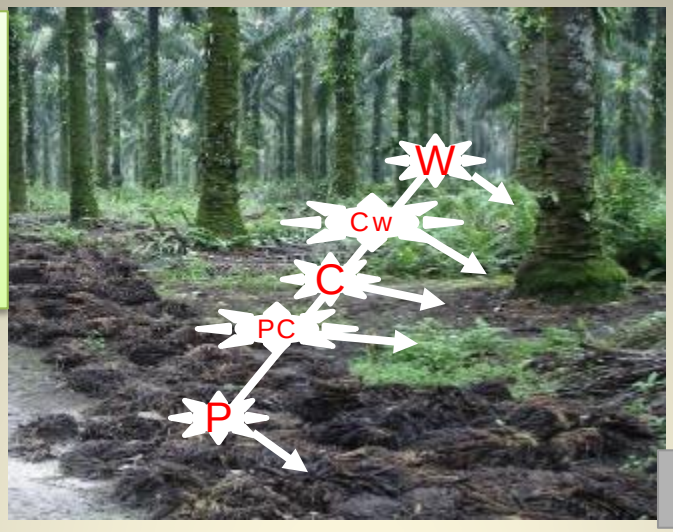
-/--/--- Less than "W zone in EFB"

Soil parameters	With EFB P	PC	C	CW	W
pH	+				←
P	+		++		←
K	+++	+	++		←
CEC	-		+		←
Ca			+	-	←
Mg	+	+	++		←
Saturation	+++	++	++		←
Organic cover (biomass)		- -		-	←
Macrofauna (biomass)	-	+	+		←
Macrofauna (Density)	-	-		-	←
Earthworms (Density)	- -	++	-	-	←
Ants (Density)	- -	- - -		-	←
Dermaptera (Density)	- - -	- - -			←

→ Spatial variability (Master Q. Auriac, 2012)

Analysis was made 3 months after EFB application on P zone.

Soil depth: 0 – 15 cm



Reference = W zone "with EFB"

No difference

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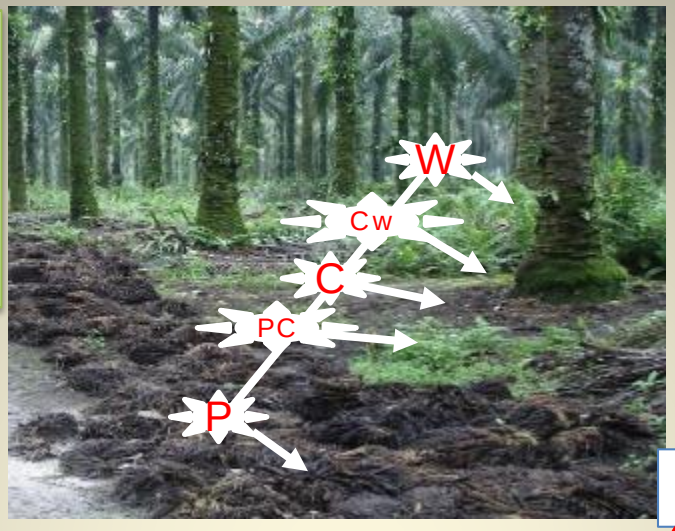
-/--/--- Less than "W zone in EFB"

Without EFB						With EFB				
P	PC	C	CW	W	Soil parameters	P	PC	C	CW	W
					pH	+				←
	++	+++			P	+		++		←
		+			K	+++	+	++		←
-	-	+			CEC	-		+		←
-	-	+		-	Ca			+	-	←
		+			Mg	+	+	++		←
		+	+		Saturation	+++	++	++		←
- - -	- - -	-	-		Organic cover (biomass)		--	-	-	←
- -			-	-	Macrofauna (biomass)	-	+	+		←
- -	-	-	-		Macrofauna (Density)	-	-		-	←
- -	-	++	-	-	Earthworms (Density)	--	++	-	-	←
- - -	-	-	-		Ants (Density)	--	---		-	←
- - -	- - -			-	Dermaptera (Density)	---	---			←

→ Spatial variability (Master Q. Auriac, 2012)

Analysis was made 3 months after EFB application on P zone.

Soil depth: 0 – 15 cm



Reference = W zone "with EFB"

No difference

+/++/+++ More than "W zone in EFB"

-/--/--- Less than "W zone in EFB"

Impact "with EFB"/"without EFB"

Increase

Decrease

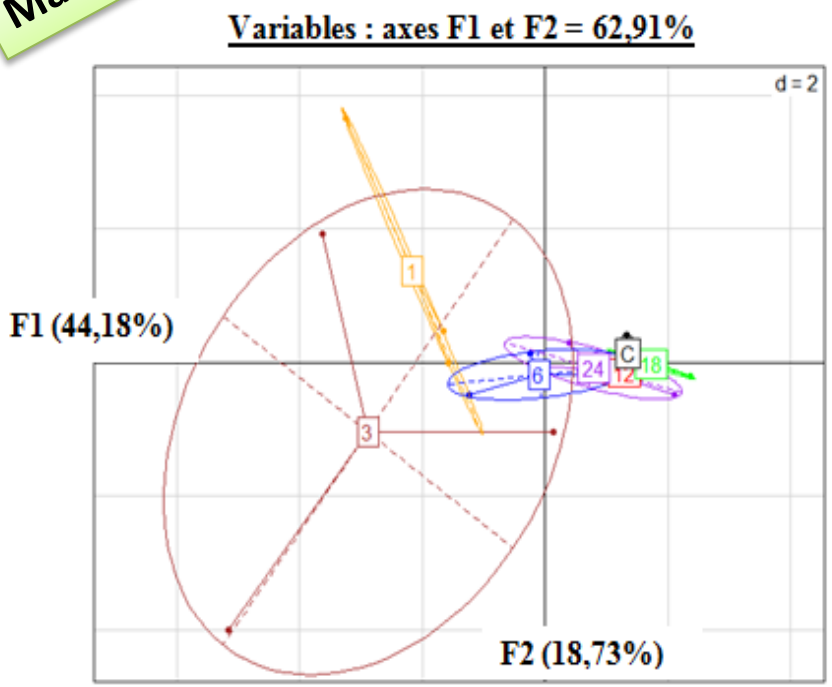
Without EFB						With EFB				
P	PC	C	CW	W	Soil parameters	P	PC	C	CW	W
					pH	+				←
	++	+++			P	+		++		←
		+			K	+++	+	++		←
-	-	+			CEC	-		+		←
-	-	+		-	Ca			+	-	←
		+			Mg	+	+	++		←
		+	+		Saturation	+++	++	++		←
- - -	- - -	-	-		Organic cover (biomass)		- -	-	-	←
- -			-	-	Macrofauna (biomass)	-	+	+		←
- -	-	-	-		Macrofauna (Density)	-	-		-	←
- -	-	++	-	-	Earthworms (Density)	- -	++	-	-	←
- - -	-	-	-		Ants (Density)	- -	- - -		-	←
- - -	- - -			-	Dermaptera (Density)	- - -	- - -			←

→ Temporal variability (MFE M. Pierrat, 2013)

With EFB : analysis of humic soil layer (3.5 cm) on P zone, 1 to 24 months after application

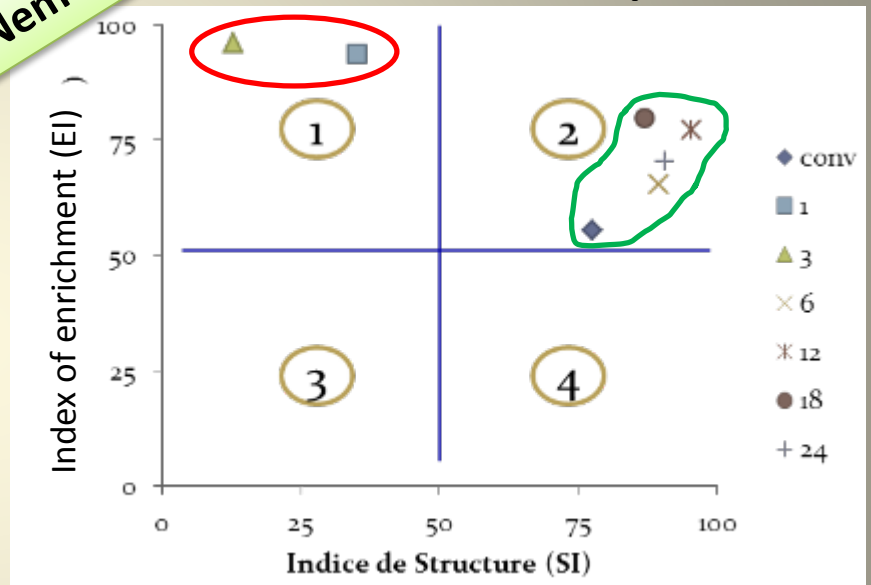
Macrofauna

Principal Component Analysis



Nematofauna

Structure of the soil trophic chain



1 : Disturbed, Enriched in N, Low C:N, Bacterial, Conductive
2 : Mature, Enriched in N, Low C:N , Bacterial, regulated
3 : Degraded, Depleted C:N, Fungi, Conductive
4 : Mature, Fertile, Average C:N,balanced Bact/Fong, Suppressive

→ Temporal variability (MFE M. Pierrat, 2013)

Changes in organic soil layer (0 to 3.5 cm) on P zone - 1 to 24 months after EFB application

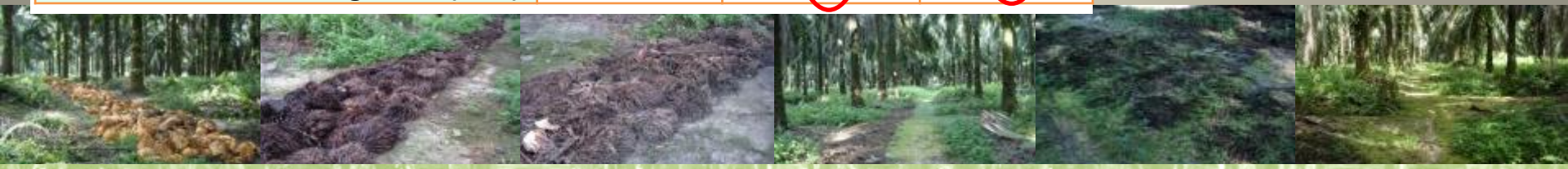
	1 to 6 mo.	12 to 18 mo.	24 mo.
Bulk density	+	++	+++
C organic	+	+	++
pH	+++	+	
N tot	+	+	++
K	+++	+	+
CEC	++	+	+++
Ca	+	++	++
Saturation	+++	++	+
Organic cover (biomass)	+++	++	+
Macrofauna density	+++	+	++
• Earthworms	-	++	+++
• Ants	+++	+	+
• Coleoptera	+++		++
• Diplopodes	- - -	+	+++
• Dermaptera	+	+	+++
Nematofauna density		++	++
• N bacterivorous		+	++
• Maturity Index (MI)	-		
• Index for breaking down (NCR)	+		

Reference = conventional P zone "without EFB"

No difference

+/++/+++ More

-/--/--- Less



Conclusions and Outlooks

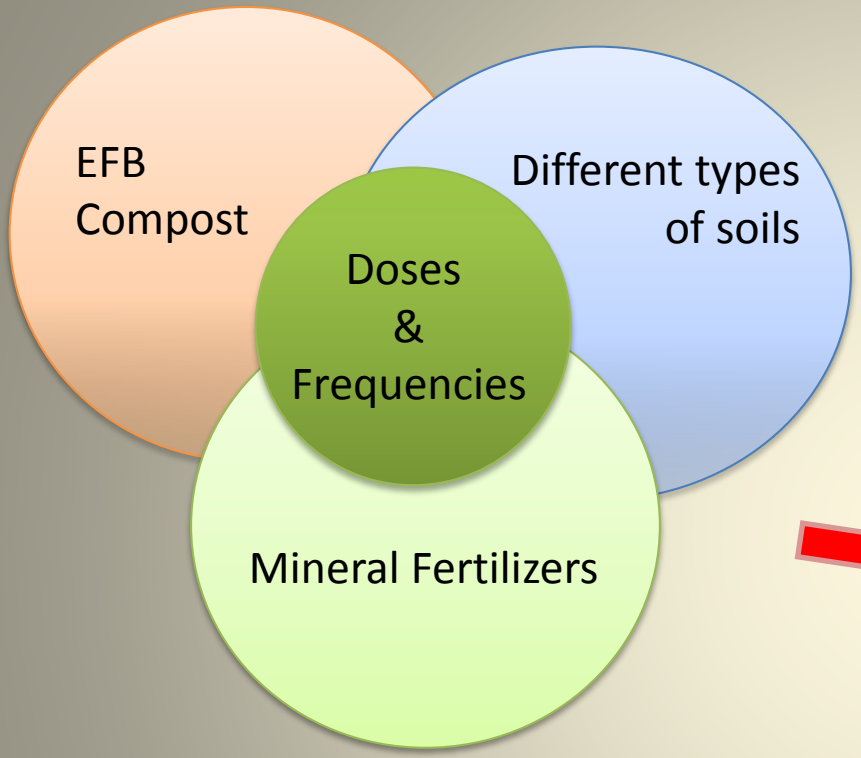
- EFB inputs impacted the soil outside of the zone of application (harvesting path), especially regarding soil macrofauna and microbes.

- During a period of 3 to 6 months after EFB application, Soil Chemical and Fauna traits were strongly disturbed. There is need to:
  - Understand the origins and ways of this disturbance;
  - Study the traits and impacts of composts, as an alternative recycling way.

- The period from 6 to 18 months after EFB application looked like a resilience time.

- At 24 months after application of EFB, most of the traits of comprehensive soil fertility were still improving (except K content). There is need to:
  - Know the duration of this last period;
  - Assess new organic and mineral fertilization practices using:
    - Organic waste to optimize soil biology and ecosystemic services;
    - Mineral fertilizers to complement organic fertilizers regarding mineral requirements of palms.

Conclusions and Outlooks



Soil quality balance sheet
in pre-existing field trial

Combination of mineral & organic inputs for a synergic effect on soil quality and plant nutrition/production
in a new field trial

Analyses foreseen:
- Foliar diagnosis
- Soil diagnosis (Physical-chemical, macrofauna, microorganisms, SOM partitioning, microbial biomass)

Field parameters:
- Yield,
- Fertilisation practices